EVALUATION OF CANDIDATE CHEMOSTERILANTS FOR THE BOLL WEEVIL

Production Research Report No. 120

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with
Mississippi State University Agricultural
Experiment Station

Contents

	Page
Methods and materials	1
Results	2
Discussion	22
Summary	23
Literature cited	24

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

Mention of a proprietary product or commercial organization in this publication does not constitute a guarantee or warranty by the U.S. Department of Agriculture over other products or organizations not mentioned.

Washington, D.C. Issued January 1971

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 25 cents

EVALUATION OF CANDIDATE CHEMOSTERILANTS FOR THE BOLL WEEVIL

By Jack W. Haynes, Norman Mitlin, T. B. Davich, and C. E. Sloan, *Entomology Research Division, Agricultural Research Service*

The Boll Weevil Research Laboratory at State College, Miss., has evaluated over 200 potential chemosterilants against the boll weevil (*Anthonomus grandis* Boheman). Generally the materials chosen for evaluation had shown activity against some biological system or had belonged to a class of closely related compounds. They included many alkylating agents and antimetabolites, types of compounds that already have been reported to be effective chemosterilants (Borkovec *1*).[1]

Several materials were tested in conjunction with the alkylating agent apholate, which has been the most effective sterilant of the boll weevil (Haynes and others *7*). Unfortunately it destroys the mitotic tissue of the midgut, materially affecting the vigor of the insect (Riemann and Flint *10*). It was hoped that the concentration of apholate could thereby be reduced, along with the consequent ill effects, should potentiation or augmentation occur. Since the damaging effects of the alkylating agent are identical to those caused by radiation, it was reasoned that the conjunctive use of chemical radioprotective agents might prevent or decrease these debilitating effects.

Several 3,4-(methylenedioxy)phenyl compounds were evaluated, which had been reported to be effective growth inhibitors and female sterilants (Mitlin *8*, Mitlin and Baroody *9*). More recently these compounds have been shown to work well in combination with insect hormone-type compounds (Bowers *2*).

METHODS AND MATERIALS

All compounds were tested by dipping, feeding, or topical application. All tests were made with 20–50 newly emerged laboratory-reared weevils, generally of mixed sexes. If the chemical was promising, it was retested against sexed weevils. All chemical solutions were prepared daily on a weight-to-volume basis just before use.

In dipping tests the five solvents used in order of preference were water (H_2O), ethanol, methanol, dimethylformamide (DMF), and dimethyl sulfoxide (DMSO). If water was used, the weevils received a single 15-second dip. A single 5-second dip was made when any of the other solvents were used, since they were undiluted and high mortality resulted with longer dips.

Prior to dipping, the weevils were anesthetized with carbon dioxide. The anesthetized weevils were easier to handle and mortality was not a factor. After they were dipped, they were allowed to dry and then put into containers.

Feeding tests were conducted by incorporating the desired candidate chemosterilant in a 10-percent sucrose solution. The insects were placed in pint ice cream cartons with screen tops. Pieces of absorbent cotton were placed on top of the carton and saturated with the sucrose solution containing the chemosterilant, and the weevils were allowed to feed for 48 hours.

Topical treatments were made with a microapplicator equipped with a No. 31 gage needle. Each insect received 1.4 ml. of liquid applied to

[1] Italic numbers in parentheses refer to Literature Cited, p. 24.

the dorsal abdominal region. Acetone was the solvent used.

After the treatment all insects were mated and placed in pint ice cream cartons provided with screen tops and held at 25.6°–26.6° C. They were fed adult diet pellets (Gast *6*) or cotton squares if available. Eggs were collected and placed on wet filter paper. They were observed daily up to 7 days and hatch was recorded. Mortality was noted at the end of the first and second week after treatment. If it was excessive after the first week, the test usually was discontinued.

When insects were treated with the 3,4-(methylenedioxy) phenyl compounds, the eggs were surface sterilized with 0.5 percent sodium hypochlorite for 1 hour, drawn up into a syringe, spread over the diet plates, and checked for hatch and development for 2 weeks in an incubator at 29.5° C.

RESULTS

The following candidate chemosterilants screened alone effectively sterilized 75 percent or more of the eggs collected (table 1) :

Entomology No. (ENT–)	*Chemical name*
50173	1-aziridinecarboxamide, *N,N'*-(4-methyl-*m*-phenylene) bis-
50664	1-aziridinecarboxamide, *N,N'*-1,5-naphthylenebis-
50987	1-aziridinecarboxamide, *N,N'*-vinylenebis-, *trans*-
50825	porfiromycin
50451	carbamic acid, [bis(1-aziridinyl)-phosphinyl]-, benzyl ester
50450	carbamic acid, [bis(1-aziridinyl)-phosphinyl]-, ethyl ester
51134	cobalt, dichlorobis[tris(1-aziridinyl)-phosphine oxide]-
61461	methanetrisulfonic acid, trimethyl ester
24915	tepa
50003	metepa
50004	methiotepa
50981	phosphinothioic amide, *P,P*,-bis(1-aziridinyl)-*N*-(3-methoxypropyl)
50882	hempa
28009	triphenyltin hydroxide
50123	methylapholate
25296	tretamine
50055	methyl tretamine
50781	urea, 1-[bis(1-aziridinyl) phosphinyl]-3-(3,4-dichlorophenyl)-

Mortality of the adult weevils treated with these chemosterilants ranged from 30 to 100 percent with three exceptions. Eggs collected from weevils dipped in a 12-percent solution of 1-aziridinecarboxamide, *N,N'*-1,5-naphthylenebis- proved to be 91-percent nonviable, and adult mortality was 12 percent after 14 days. A 1.5-percent concentration of tretamine sterilized 93 percent of the eggs collected during the test, and mortality of the treated insects was 11 percent after 14 days. Eggs collected from weevils dipped in a 10-percent concentration of urea, 1-[bis(1-aziridinyl) phosphinyl]-3-(3,4-dichlorophenyl)- proved to be 100-percent sterile, and mortality of treated adults ranged from 14 to 60 percent after 14 days.

The following chemical combinations sterilized 75 percent or more of the eggs collected (table 2) :

apholate + piperonyl butoxide
apholate + propyl isome
apholate + sesamex
apholate + Bucarpolate
apholate + carbazole
carbazole + tretamine
piperonyl butoxide + 1-[bis(1-aziridinyl)-phosphinyl]-3-(3,4-dichlorophenyl)urea
piperonyl butoxide + methiotepa
6-thioguanine + apholate

Mortality was higher than 30 percent with all these combinations tested except with 1-percent apholate plus 1-percent piperonyl butoxide, 1-percent apholate plus 1-percent Bucarpolate, and 1-percent apholate plus 2-percent carbazole, which sterilized 100, 86, and 94 percent of the eggs collected, respectively, but killed only 30, 15, and 10 percent of the adult weevils, respectively, 14 days after treatment.

Three derivatives of 3,4-(methylenedioxy) phenyl proved to be the most effective of those screened topically (table 3) ; di-2-propynyl (6-propylpiperonyl) phosphonate when tested against males reduced egg hatch to about 56 percent at 1, 5, and 10 mg. per milliliter; 4,5-(methylenedioxy)-2-propyl-α-(2-propynyloxy)-toluene when tested against both sexes reduced egg hatch to about 38 percent at 10 mg. per milliliter; and sesamex at 1 mg. per milliliter reduced egg hatch to about 6 percent when both sexes were treated. Emergence also was generally lower than that of the control group.

TABLE 1.—*Results of general chemosterilant screening against adult boll weevils by dipping, feeding, and topical treatment. (1 replication of 20–50 weevils per test)*

Chemical name	Entomology No. (ENT–)	Concentration	Solvent	Method applied	Sterile eggs	Mortality after 7–14 days
		Percent			*Percent*	*Percent*
Acetamide, 2 amidino-2-(phenylazo)-, hydrochloride	51982	1	H_2O	Dip [1]	8	0
Acetamide, *N,N'*-(tetramethyl-*p*-phenylene)bis[2-chloro-*N*-cyclohexyl-	51188	10	Ethanol	Dip	2	4
		.5		Fed [2]	10	6
Acetanilide, *N,N'*-trimethylenebis-[2-chloro-	51176	10	DMF	Dip	2	42
		.5		Fed	4	18
Acetic acid, mercaptophenyl-, ethyl ester, *S*-ester with *O,O*-dimethyl phosphorodithioate	27386	1.25	Ethanol	Dip	[3]	100
		2.5	....do	Dip	[3]	100
		5	....do	Dip	[3]	100
Acetohydroxamic acid, *N*-fluoren-2-yl-	50466	1	DMSO	Dip [1]	10	50
		1	DMSO	Dip [4]	0	40
Acetonitrile, (purin-6-ylthio)-	50856	10	DMSO	Dip	3	44
		2		Fed	0	54
Acrylamide, *N,N'*-methylenebis-	8643	10	DMSO	Dip	0	58
		.1		Fed	0	94
Adenine, *N,N*-diethyl-	51952	.0012	Ethanol	Topical [1]	13	0
		.0012	....do	....do.[4]	5	30
		.0025	....do	....do.[1]	11	10
		.0025	....do	....do.[4]	5	0
		.005	....do	....do.[1]	0	20
		.005	....do	....do.[4]	9	10
		.010	....do	....do.[1]	0	0
		.010	....do	....do.[4]	4	10
Alanine, 3-[*p*-[bis(2-chloroethyl)-amino]phenyl]-, DL-	25298	2	H_2O	Dip	11	14
		1		Fed	67	65
Ammonium, hexadecyltrimethyl- - - - bromide	12209	2	H_2O	Dip	1	20
		10	H_2O	Dip	18	28
		.5		Fed	4	20
		2		Fed	1	20
Aniline, *N,N*-diethyl-*p*-nitroso-	15392	1	H_2O	Dip [1]	8	0
Aziridine, 1,1'-adipoylbis-	50610	1	H_2O	Dip [1]	8	12
		2	H_2O	Dip	0	85
		.5		Fed	0	30

See footnotes at end of table.

TABLE 1.—*Results of general chemosterilant screening against adult boll weevils by dipping, feeding, and topical treatment. (1 replication of 20–50 weevils per test)*—Continued

Chemical name	Entomology No. (ENT–)	Concentration	Solvent	Method applied	Sterile eggs	Mortality after 7–14 days
		Percent			*Percent*	*Percent*
Aziridine, 1,1′-azelaoylbis-	50611	1	H_2O	Dip	0	10
		2	H_2O	Dip	0	85
		10	H_2O	Dip	5	0
		.5		Fed	2	4
Aziridine, 1-(*p*-chlorobenzoyl)-	50407	10	DMF	Dip	1	28
		2		Fed	1	16
Aziridine, 1,1′-fumaroylbis-	50616	1	H_2O	Dip	4	9
		2	H_2O	Dip	0	75
		10	H_2O	Dip	26	8
Aziridine, 2-methyl-	50325	10	H_2O	Dip	1	8
		.5		Fed	6	4
Aziridine, 1,1′-oxalylbis-	50888	10	H_2O	Dip	6	10
		.5		Fed	2	0
Aziridine, 1-propionyl-	50890	10	H_2O	Dip	1	3
		.5		Fed	4	12
Aziridine, 1,1′-sebacoylbis-	50612	10	H_2O	Dip	7	20
		.5		Fed	1	0
Aziridine, 1,1′-suberoylbis-	50889	10	H_2O	Dip	9	2
		.5		Fed	2	4
Aziridine, 1,1′-sulfinylbis[2-methyl-	50358	10	H_2O	Dip	0	96
		.5		Fed	0	92
Aziridine, 1,1′-terephthaloylbis-	50526	10	DMF	Dip	8	44
		.5		Fed	0	4
Aziridine, 1-1,*o*-toluoyl	50550	2	DMSO	Dip	4	20
		.5		Fed	8	10
1-Aziridinecarboxamide, *N*,*N*′-hexamethylenebis-	50172	.5	H_2O	Dip	0	11
		2	H_2O	Dip	41	38
		1		Fed	50	100
1-Aziridinecarboxamide, *N*,*N*′-hexamethylenebis[2-methyl-	50885	2	H_2O	Dip	21	36
1-Aziridinecarboxamide, *N*,*N*′-(methylenedi-*p*-phenylene)bis-	50175	10	DMSO	Dip	6	2
		.5		Fed	12	2
		2		Fed	17	74

TABLE 1.—*Results of general chemosterilant screening against adult boll weevils by dipping, feeding, and topical treatment. (1 replication of 20–50 weevils per test)*—Continued

Chemical name	Entomology No. (ENT–)	Concentration	Solvent	Method applied	Sterile eggs	Mortality after 7–14 days
		Percent			*Percent*	*Percent*
1-Aziridinecarboxamide, *N,N'*-(4-methyl-*m*-phenylene)bis-	50173	1	H_2O	Dip	4	15
		2	H_2O	Dip	58	50
		1		Fed	87	92
1-Aziridinecarboxamide, *N,N'*-(4-methyl-*m*-phenylene)bis[2-methyl-	50887	2	H_2O	Dip	22	24
1-Aziridinecarboxamide, *N,N'*-1,5-naphthylenebis-	50664	2	H_2O	Dip	13	2
		10	H_2O	Dip	58	5
		12	H_2O	Dip	91	12
		15	H_2O	Dip	100	32
		.5		Fed	8	4
1-Aziridinecarboxamide, N-octadecyl-	50169	10	Ethanol	Dip	4	24
		.5		Fed	8	10
1-Aziridinecarboxamide, *N,N'*-(*o*-phenylenedimethylene)bis-	50174	2	H_2O	Dip	31	11
		1		Fed	33	83
1-Aziridinecarboxamide, *N*-propyl-	50170	6	H_2O	Dip	9	6
		.5		Fed	15	10
1-Aziridinecarboxamide, *N,N*-tetramethylenebis-	50838	5	H_2O	Dip	(3)	82
		10	H_2O	Dip	(3)	100
		2		Fed	(3)	100
1-Aziridinecarboxamide, *N,N'*-vinylenebis-, *trans*-	50987	.312	Ethanol	Dip	10	4
		1.25	....do	Dip	67	58
		2.5	....do	Dip	89	66
		3.0	....do	Dip	100	36
		4.0	....do	Dip	100	50
		5.0	....do	Dip	100	30
		10.0	....do	Dip	100	74
		.25		Fed	(3)	100
		.5		Fed	93	75
		1.0		Fed	(3)	100
		2.0		Fed	100	36
		5.0		Fed	62	4
1-Aziridinecarboxanilide	50171	10	Ethanol	Dip	4	38
		.5		Fed	16	6
1-Aziridinecarboxanilide, 4',4''',4'''''-methylidynetris-	50176	10	DMF	Dip	0	6
		.5		Fed	10	6
2-Aziridineethanol, polymer (50-percent aqueous solution)	50177	1	H_2O	Dip	6	15
		2	H_2O	Dip	1	28
		.5		Fed	10	6

See footnotes at end of table.

TABLE 1.—*Results of general chemosterilant screening against adult boll weevils by dipping, feeding, and topical treatment. (1 replication of 20–50 weevils per test)*—Continued

Chemical name	Entomology No. (ENT–)	Concentration	Solvent	Method applied	Sterile eggs	Mortality after 7–14 days
		Percent			*Percent*	*Percent*
1-Aziridinemethanol, α-(trichloromethyl)-	50891	10	H_2O	Dip	2	6
		.5		Fed	2	6
Azirino[2′,3′:3,4]pyrrolo[1,2-*a*]indole-4,7-dione, 6-amino-1,1a,2,8,8a,8b,-8-(hydroxymethyl)-8a-methoxy-1,5-dimethyl-, carbamate (porfiromycin)	50825	10	DMSO	Dip	29	24
		.1		Fed	94	60
Benzene, 4-[(6,7-epoxy-3,7-dimethyl-2-octenyl)oxy]-1,2-(methylenedioxy)-, *trans*-	70033	.001	Acetone	Topical [1]	3	20
		.001	....do	....do.[4]	3	0
Benzenearsonous acid, *p*-[(4,6-diamino-*s*-triazin-2-yl)amino]dithio-, diester with mercaptoacetic acid, disodium salt	51157	2	H_2O	Dip	8	4
		10	H_2O	Dip	10	22
p-Benzoquinone, 2,5-bis(dimethylamino)-	50904	10	Ethanol	Dip	2	2
		.5		Fed	4	0
1*H*-Benzotriazole-1-methanol, 5,6-dimethyl-	52182	1	DMF	Dip [1]	8	20
		1	DMF	Dip [4]	10	30
Biguanide, 1-(*p*-chlorophenyl)-	52174	1	DMF	Dip [1]	18	10
		1	DMF	Dip [4]	8	10
1,4-Butanediol, dimethanesulfonate (busulfan)	25012	.25	H_2O	Dip	0	18
		.5	H_2O	Dip [1]	4	28
		1	H_2O	Dip	0	32
		2	H_2O	Dip	0	28
		2	DMSO	Dip [1]	60	85
		1		Fed	8	15
Butyric acid, 4-[*p*-[bis(2-chloroethyl) amino]phenyl]- (chlorambucil)	26083	2	H_2O	Dip	0	63
		1		Fed	49	65
Butyric acid, 4-hydroxy-2-mercapto-, γ-lactone, *S*-ester with *O,O*-diethyl phosphorothioate	27333	10	Ethanol	Dip	0	100
Carbamic acid, phenyl ester	50866	10	....do	Dip	(3)	100
Carbamic acid, [bis(1-aziridinyl)-phosphinyl]-, benzyl ester	50451	10	....do	Dip	3	72
		.5		Fed	85	54
Carbamic acid, [bis(1-aziridinyl)-phosphinyl]-, ethyl ester	50450	8	H_2O	Dip	0	80
		10		Fed	90	74
		.5		Fed	0	84

See footnotes at end of table.

TABLE 1.—*Results of general chemosterilant screening against adult boll weevils by dipping, feeding, and topical treatment. (1 replication of 20–50 weevils per test)*—Continued

Chemical name	Entomology No. (ENT–)	Concentration	Solvent	Method applied	Sterile eggs	Mortality after 7–14 days
		Percent			*Percent*	*Percent*
Carbamic acid, ethylenebis[ethyl-, diethyl ester	52171	1	Methanol	Dip [1]	0	0
		1	do	Dip [4]	6	10
Carbamic acid, [2-hydroxy-1-(hydroxymethyl)ethyl]-, 2-chloro-1-(chloromethyl) ethyl ester	28271	10	H_2O	Dip	1	24
		2		Fed	6	16
Carbamic acid, (2,2,3-trichloro-1-hydroxybutyl-, butyl) ester	22675	10	H_2O	Dip	6	12
Carbanilic acid, isopropyl ester	14879	1	DMF	Dip [1]	16	50
		1	DMF	Dip [4]	4	30
5β-Cholest-7-en-6-one, 2β,3β,14,20,22,25-hexahydroxy-, (22*R*)- (ecdysterone)	44727	.001	Acetone	Topical [1]	3	0
5β-Cholest-7-en-6-one, 2β,3β,14-trihydroxy-	70034	.001	do	do.[1]	9	7
		.001	do	do.[4]	19	0
5β,20-Cholest-7-en-6-one, 2β,3β,14,20,22,26-hexahydroxy-(inokosterone)		.001	do	do.[1]	3	7
		.001	do	do.[4]	3	7
Choline, acetyl-, bromide	18298	10	H_2O	Dip	6	8
		2		Fed	2	30
Chromium, dichlorotetrakis(ethylenimine)- - - -chloride, *trans*-	50873	10	H_2O	Dip	2	28
		.5		Fed	2	4
Cobalt, bis(dimethylglyoximato)bis-(ethylenimine)- - - -chloride	50872	10	H_2O	Dip	9	8
		.5		Fed	2	28
Cobalt, bis(ethylenediamine)bis-(ethylenimine)- - - -tribromide	50874	10	H_2O	Dip	9	2
		.5		Fed	2	4
Cobalt, dichlorobis[tris(1-aziridinyl)-phosphine oxide]-	51134	10	H_2O	Dip	41	44
		15		Fed	25	42
		2		Fed	100	82
1,2,4-Dithiazolium, 3,5-bis-(dimethylamino)- - - -chloride	51160	5	H_2O	Dip	[3]	98
		10	H_2O	Dip	[3]	84
		.5		Fed	[3]	98
Ethanol, 1,1′-[(6-amino-s-triazine-2,4-diyl) diimino]bis[2,2,2-trichloro-	51121	10	DMF	Dip	3	58
		.5		Fed	7	18
Ethylenimine	50324	10	H_2O	Dip	0	8
		.5		Fed	4	0

See footnotes at end of table.

TABLE 1.—*Results of general chemosterilant screening against adult boll weevils by dipping, feeding, and topical treatment. (1 replication of 20–50 weevils per test)*—Continued

Chemical name	Entomology No. (ENT–)	Concentration	Solvent	Method applied	Sterile eggs	Mortality after 7–14 days
		Percent			*Percent*	*Percent*
Flavanone, 3,3′,4′,5,7-pentahydroxy-(dihydroquercetin)	52769	10	H_2O	Dip	3	4
		25	H_2O	Dip	6	8
		2		Fed	(3)	100
		2		Fed	6	12
Fluorene-2,7-diamine	50463	10	H_2O	Dip	0	8
		.5		Fed	4	0
Glucaric acid, dipotassium salt	50366	2	H_2O	Dip	5	0
		1		Fed	4	28
Glycerol, trimethanesulfonate	61169	2	DMSO	Dip [1]	50	70
Guanazole	51272	10	H_2O	Dip	10	20
		.5		Fed	8	4
Guanidine, (benzylideneamino)-, nitrate	52004	2	Ethanol	Dip	28	10
		1		Fed	0	10
Guanidine, methyl-, hydrochloride	51270	10	H_2O	Dip	4	18
		.5		Fed	3	46
2-Imidazolidinone	22151	1	H_2O	Dip	5	0
		2	H_2O	Dip	1	0
		5	H_2O	Dip	5	0
		1	H_2O	Dip	0	0
		1		Fed	0	0
Isothiocyanic acid, s-triazine-2,4,6-triyl ester	51101	10	DMF	Dip	4	8
		.5		Fed	16	16
Ketone, methyl 3-pyridyl	50031	10	H_2O	Dip	6	6
		.5		Fed	13	8
Mannitol, 1,6-bis[(2-chloroethyl)amino]-1,6-dideoxy-, dihydrochloride, D- (mannitol nitrogen mustard)	50454	1	H_2O	Dip	0	25
		2	H_2O	Dip	5	0
		.25		Fed	(3)	100
		.5		Fed	68	52
Melamine, N^2-butyl-N^4-octyl-N^6-propyl-	51169	10	Ethanol	Dip	0	42
		.5		Fed	16	18
Melamine, N^2,N^2-diethyl-N^4,N^4-dimethyl-N^6,N^6-dipropyl-	51227	10	Ethanol	Dip	(3)	96
Melamine, N^2,N^4-dimethyl-	51237	10	H_2O	Dip	4	16
		2		Fed	2	18

See footnotes at end of table.

TABLE 1.—*Results of general chemosterilant screening against adult boll weevils by dipping, feeding, and topical treatment. (1 replication of 20–50 weevils per test)*—Continued

Chemical name	Entomology No. (ENT–)	Concentration	Solvent	Method applied	Sterile eggs	Mortality after 7–14 days
		Percent			*Percent*	*Percent*
Melamine, (dodecylphenyl)-	51167	10	DMF	Dip	2	50
		.5		Fed	8	8
Melamine, ethyl-	51196	2	H_2O	Dip	5	4
		10	H_2O	Dip	5	42
		10	Ethanol	Dip	7	30
		2		Fed	6	22
Melamine, hexamethyl-	50852	2	Ethanol	Dip	4	4
		.5		Fed	8	2
Melamine, isopropyl-	51195	10	Ethanol	Dip	1	12
		2		Fed	6	10
Melamine, methyl-, hydrochloride	51216	2	H_2O	Dip	0	0
		10	H_2O	Dip	7	20
		.5		Fed	20	18
Melamine, octadecyl-	51095	10	DMF	Dip	2	48
		.5		Fed	10	12
Melamine, pentamethyl-	51239	10	Ethanol	Dip	7	22
		2		Fed	13	18
Melamine, pentamethyl-, hydrochloride	51240	10	H_2O	Dip	7	16
		.5		Fed	6	12
Melamine, propyl-	51197	10	H_2O	Dip	17	18
		.5		Fed	5	29
Melamine, N^2,N^2,N^4,N^4-tetramethyl-, hydrochloride	51146	10	H_2O	Dip	2	30
		.5		Fed	2	32
Melamine, N^2,N^2,N^4,N^6-tetramethyl-	51243	10	Ethanol	Dip	7	60
		2		Fed	6	18
Melamine, N^2,N^2,N^4,N^6-tetramethyl-, hydrochloride	51244	10	H_2O	Dip	3	18
		.5		Fed	27	28
Melamine, (1,1,3,3-trimethylbutyl)-	51126	10	Ethanol	Dip	1	16
		.5		Fed	6	14
Melamine, N^2,N^4,N^6-tri-*tert*-butyl-	51165	10	Ethanol	Dip	4	58
Melamine, N^2,N^4,N^6-tributyl-N^2,N^4,N^6-trimethyl-	51228	10	....do	Dip	9	90
		.5		Fed	23	8

TABLE 1.—*Results of general chemosterilant screening against adult boll weevils by dipping, feeding, and topical treatment. (1 replication of 20–50 weevils per test)*—Continued

Chemical name	Entomology No. (ENT–)	Concentration	Solvent	Method applied	Sterile eggs	Mortality after 7–14 days
		Percent			*Percent*	*Percent*
Melamine, N^2,N^2,N^4-trimethyl-	60020	2	Ethanol	Dip	0	12
		5	....do	Dip	0	16
		10	....do	Dip	1	16
		2		Fed	5	6
Melamine, N^2,N^2,N^4-trimethyl-, hydrochloride	60021	2	H_2O	Dip	5	4
		5	H_2O	Dip	6	8
		10	H_2O	Dip	5	16
Melamine, N^2,N^4,N^6-trimethyl-	51035	10	H_2O	Dip	36	30
		.5		Fed	14	30
Melamine, N^2,N^4,N^6-trimethyl-, hydrochloride	51242	10	H_2O	Dip	21	10
		.5		Fed	3	18
Mercury, acetoxyphenyl-	14668	10	DMF	Dip	(3)	100
		2		Fed	4	92
Methanediol, dimethanesulfonate	51799	2	DMSO	Dip [1]	68	65
Methanesulfonamide, *N,N*-bis(2-hydroxyethyl)-, dimethanesulfonate	61174	2	DMSO	Dip [1]	58	55
Methanetrisulfonic acid, trimethyl ester	61461	2	DMSO	Dip [1]	100	95
Nickel, bis(dimethyldithiocarbamato)-	50831	10	Mineral oil	Dip	(3)	100
		.5		Fed	1	38
Orotic acid, 5-fluoro-	26398	10	DMSO	Dip	2	24
		.5		Fed	4	14
2*H*-1,3,2-Oxazaphosphorine, 2-[bis(2-chloroethyl)amino]tetrahydro-, 2-oxide (endoxan)	26198	2	H_2O	Dip	8	25
		.5		Fed	4	40
Pactamycin (from *Streptomyces pactum* var. *pactum*)	51038	1	Ethanol	Dip	1	2
		2	....do	Dip	2	28
		5	....do	Dip	3	70
		10	....do	Dip	2	86
		.5		Fed	(3)	100
		1		Fed	(3)	100
Pentaerythritol, tetramethanesulfonate	61236	2	DMSO	Dip [1]	38	35
Peroxycarbamic acid, dimethyltrithio-, *tert*-butyl ester	25031	2	H_2O	Dip	2	46
		.5		Fed	6	4

See footnotes at end of table.

TABLE 1.—*Results of general chemosterilant screening against adult boll weevils by dipping, feeding, and topical treatment. (1 replication of 20–50 weevils per test)*—Continued

Chemical name	Entomology No. (ENT–)	Concentration	Solvent	Method applied	Sterile eggs	Mortality after 7–14 days
		Percent			*Percent*	*Percent*
Phenol, *o*-[(*m*-nitrobenzylidene)amino]-	51257	10	DMSO	Dip	11	18
		.5		Fed	1	14
Phosphine oxide, bis(2-methyl-1-aziridinyl)- (phenyl MAPO)	50005	1	H_2O	Dip	9	18
		1		Fed	60	90
Phosphine oxide, tris(1-aziridinyl)- (tepa)	24915	.5	H_2O	Dip	65	20
		1	H_2O	Dip	72	16
		2	H_2O	Dip	88	69
		1		Fed	50	90
Phosphine oxide, tris(2-methyl-1-aziridinyl)- (metepa)	50003	.5	H_2O	Dip	20	43
		2	H_2O	Dip	9	37
		.25		Fed	(3)	100
		.5		Fed	80	78
Phosphine sulfide, tris(2-methyl-1-aziridinyl)- (methiotepa)	50004	1	H_2O	Dip	55	43
		2	H_2O	Dip	98	82
Phosphinothioic amide, *P*,*P*-bis(1-aziridinyl)-*N*-(3-methoxypropyl)-	50981	2	Ethanol	Dip	100	88
		5	....do	Dip	(3)	100
		10	....do	Dip	(3)	100
		2		Fed	(3)	100
Phosphonic acid, phenyl-, propyl 2-propynyl ester	28923	.001	Acetone	Topical [1]	12	0
		.001	....do	....do.[4]	5	13
Phosphonic amide, *P*,*P*-bis(1-aziridinyl)-*N*-isopropyl-	51256	10	H_2O	Dip	(3)	86
		.5		Fed	(3)	100
Phosphonic amide, *P*,*P*-bis(1-aziridinyl)-*N*-methyl-	51254	5	H_2O	Dip	(3)	88
		10	H_2O	Dip	(3)	100
		.5		Fed	(3)	100
Phosphonic amide, *P*,*P*-bis(1-aziridinyl)-*N*-propyl-	51253	2	H_2O	Dip	(3)	96
		10	H_2O	Dip	(3)	100
		2		Fed	(3)	96
Phosphonothioic acid, methyl-, *O*-(2-chloroethyl) *O*-(α,α,α-trifluoro-4-nitro-*m*-tolyl) ester	51098	5	Ethanol	Dip	(3)	100
		10	....do	Dip	(3)	100
Phosphoric triamide, *N''*-ethyl-*N*,*N*,*N'*,*N'*-tetramethyl-	51199	2	H_2O	Dip	4	2
		10	H_2O	Dip	10	50
		.5		Fed	10	14

See footnotes at end of table.

TABLE 1.—*Results of general chemosterilant screening against adult boll weevils by dipping, feeding, and topical treatment. (1 replication of 20–50 weevils per test)*—Continued

Chemical name	Entomology No. (ENT–)	Concentration	Solvent	Method applied	Sterile eggs	Mortality after 7–14 days
		Percent			*Percent*	*Percent*
Phosphoric triamide, hexamethyl- (hempa)	50882	5	H_2O	Dip	62	12
		10	H_2O	Dip	69	40
		25	H_2O	Dip	88	49
		50	H_2O	Dip	70	77
		10	H_2O	Dip	11	10
		.5		Fed	30	2
		2		Fed	(3)	96
Phosphoric triamide, *N''*-isopropyl- *N,N,N',N'*-tetramethyl-	51163	2	H_2O	Dip	5	4
		10	H_2O	Dip	9	48
		.5		Fed	12	14
Phosphorodiamidic acid, N,N'-dimethyl-, phenyl ester	27222	2	H_2O	Dip	8	10
		5	H_2O	Dip	1	14
		10		Fed	4	20
Phthalimide, *N*-hydroxy	52074	2	Ethanol	Dip	32	10
Piperazine	26675	10	H_2O	Dip	6	12
		5		Fed		96
1,4-Piperazinedicarboxylic acid, bis[2-chloro-1-(chloromethyl)ethyl] ester	51085	2	DMF	Dip	7	12
		10	DMF	Dip	3	52
		.5		Fed	7	16
1,3-Propanediol, dimethanesulfonate	51904	1	DMSO	Dip [1]	8	10
		1	DMSO	Dip [4]	20	50
		1	H_2O	Fed	0	26
Purine, 2,6-diamino-	25010	1	DMSO	Dip [1]	16	30
		1	DMSO	Dip [4]	10	30
Purine, 2,6-dichloro-	51950	2	Ethanol	Dip	31	20
		1		Fed	9	8
Purine, 6-(phenylthio)-	52068	1	Methanol	Dip [1]	6	0
		1	....do	Dip [4]	6	0
Pyrazole-3-acetic acid, 5-amino-4- carbamoyl-	50980	10	Ethanol	Dip	3	4
		.5		Fed	6	8
3,6-Pyridazinedione, 1,2-dihydro-1- methyl-2-phenyl-	60049	2	DMSO	Dip	0	26
		5	DMSO	Dip	1	26
		10	DMSO	Dip	2	24
		2		Fed	4	42

See footnotes at end of table.

TABLE 1.—*Results of general chemosterilant screening against adult boll weevils by dipping, feeding, and topical treatment. (1 replication of 20–50 weevils per test)*—Continued

Chemical name	Entomology No. (ENT–)	Concentration	Solvent	Method applied	Sterile eggs	Mortality after 7–14 days
		Percent			*Percent*	*Percent*
Pyridinium, 1-methyl– – – –iodide	15031	10	H_2O	Dip	24	28
		.5		Fed	7	42
4,6-Pyrimidinediol, 5-nitro-	50455	1	DMSO	Dip [1]	0	50
		1	DMSO	Dip [4]	12	30
Quinaldonitrile, 1-benzoyl-1,2-dihydro-	16856	10	DMF	Dip	1	14
		.5		Fed	18	18
Streptomycin, dihydro-, sulfate	50133	.5	H_2O	Dip	10	18
		.5		Fed	10	18
Sulfamide, tetramethyl-	22946	10	Ethanol	Dip	2	6
		.5		Fed	4	4
Tin, acetoxytriphenyl- (triphenyltin acetate)	25208	.1	Ethanol	Dip	(3)	100
		.5	....do	Dip	(3)	100
		2	....do	Dip	(3)	100
		.5		Fed	(3)	100
Tin, allyltriphenyl-	50909	.006	Ethanol	Dip	2	24
		.08	....do	Dip	1	82
		.31	....do	Dip	(3)	100
		1	....do	Dip	(3)	100
		2.5	....do	Dip	(3)	100
		5	....do	Dip	(3)	100
		10	....do	Dip	(3)	100
		.5		Fed	0	96
Tin, chlorotriphenyl-	25207	.5	Ethanol	Dip	(3)	100
		2	....do	Dip	(3)	100
		.5		Fed	0	98
Tin, hydroxytriphenyl- (triphenyltin hydroxide)	28009	1	Ethanol	Dip	100	100
		.5		Fed	(3)	100
Tin, thiobis[triphenyl-	50910	10	DMF	Dip	5	96
		.5		Fed	2	4
1,3,5,2,4,6-Triazatriphosphorine, 2,4,6-tris(1-aziridinyl)-2,2,4,4,6,6-hexahydro-2,4,6-triphenyl-	50877	10	DMF	Dip	17	46
		2		Fed	2	16
		1		Fed	47	60
1,3,5,2,4,6-Triazatriphosphorine, 2,2,4,4,6,6-hexahydro-2,2,4,4,6,6-hexakis(2-methyl-1-aziridinyl)-(methylapholate)	50123	1	H_2O	Dip	31	14
		2	H_2O	Dip	30	33
		1		Fed	98	100

See footnotes at end of table.

TABLE 1.—*Results of general chemosterilant screening against adult boll weevils by dipping, feeding, and topical treatment. (1 replication of 20–50 weevils per test)*—Continued

Chemical name	Entomology No. (ENT–)	Concentration	Solvent	Method applied	Sterile eggs	Mortality after 7–14 days
		Percent			*Percent*	*Percent*
1,3,5,2,6-Triazatriphosphorine, 2,2,4,4,6,6-hexakis(dimethylamino)-2,2,4,4,6,6-hexahydro-, hydrochloride	51346	10	H_2O	Dip	4	50
		.5		Fed	2	18
s-Triazine, 2,4-diamino-6-chloro-	50982	6	H_2O	Dip	0	98
		10	H_2O	Dip	0	50
		1.2		Fed	7	12
s-Triazine, 2,4-diamino-6-(2-furyl)-	22641	10	DMF	Dip	7	70
		2		Fed	12	54
s-Triazine, 2,4-diamino-6-morpholino-, hydrochloride	51143	10	H_2O	Dip	12	20
		.5		Fed	21	20
s-Triazine, 2,4,6-tris(1-aziridinyl)-(tretamine)	25296	.5	H_2O	Dip	54	18
		1	H_2O	Dip	95	40
		1.5	H_2O	Dip	93	11
		2	H_2O	Dip	100	74
		1		Fed	83	100
s-Triazine, 2,4,6-tris(2-methyl-1-aziridinyl)- (methyl tretamine)	50055	.5	H_2O	Dip	15	16
		1	H_2O	Dip	27	23
		1.5	H_2O	Dip	3	16
		1		Fed	95	69
s-Triazine-3,5(2*H*,4*H*)-dione, 2-ribofuranosyl-	50104	2	H_2O	Dip	0	11
		.5		Fed	8	0
v-Triazolo[4,5-*d*]pyrimidin-7-ol, 5-amino- (8-azaguanine)	25015	2	H_2O	Dip	0	11
		.5		Fed	2	0
2,6-Tridecadienoic acid, 10,11-epoxy-7-ethyl-3,11-dimethyl-, methyl ester (mixed isomers synthetic juvenile hormone)	33972	.001	Acetone	Topical [1]	2	7
		.001	....do	....do.[4]	2	7
Uracil, 5,6-diamino-1,3-dimethyl-, hydrochloride	52131	2	H_2O	Dip	32	0
		1		Fed	19	40
Uracil, 5-fluoro-	25297	1	Methanol	Dip [1]	7	10
		1	....do	Dip [4]	2	10
		1	H_2O	Dip	1	18
		2	DMSO	Dip	3	26
		5	DMSO	Dip	8	16
		10	DMSO	Dip	7	44
		1		Fed	[3]	58
		2		Fed	0	70

See footnotes at end of table.

TABLE 1.—*Results of general chemosterilant screening against adult boll weevils by dipping, feeding, and topical treatment. (1 replication of 20–50 weevils per test)*—Continued

Chemical name	Entomology No. (ENT–)	Concentration	Solvent	Method applied	Sterile eggs	Mortality after 7–14 days
		Percent			*Percent*	*Percent*
Urea, 1-acetyl-2-thio-	24935	10	H_2O	Dip	12	16
Urea, 1-[bis(1-aziridinyl)phosphinyl]-3-(3,4-dichlorophenyl)-	50781	10	H_2O	Dip	100	14
		10	H_2O	Dip	100	56
		10	H_2O	Dip	100	60
		5	H_2O	Dip	93	32
		.25		Fed	100	67
Urea, hydroxy-	51139	1	H_2O	Dip [1]	12	20
		1	H_2O	Dip [4]	2	0
		1	H_2O	Dip	6	4
		3	H_2O	Dip	0	8
		10	H_2O	Dip	4	6
		1		Fed	(3)	100
Check			H_2O	Dip [5]	5	16
			Ethanol	Dip [6]	4	15
			DMSO	Dip [7]	5	28
			DMF	Dip [8]	4	15
			Mineral oil	Dip [9]	(3)	98
			Acetone	Topical [10]	8	8
			Methanol	Dip [10]	6	0
				Fed [2 6]	5	19
Confidential	51386	10	Ethanol	Dip	0	100
		.5		Fed	3	38
	51408	10	H_2O	Dip	3	34
		.5		Fed	(3)	98
	51415	10	H_2O	Dip	6	40
	51417	10	Ethanol	Dip	0	100
	51425	10	....do	Dip	11	20

[1] Treated male × normal female.
[2] 10 percent sugar water.
[3] No eggs laid.
[4] Treated female × normal male.
[5] 34 replications.
[6] 23 replications.
[7] 16 replications.
[8] 12 replications.
[9] 1 replication.
[10] 2 replications.

TABLE 2.—*Additive effects of various chemical combinations at substerilizing doses on boll weevils by dipping. (1 replication of 20–50 weevils per test)*

Compound	Concentration		Solvent	Sterile eggs	Mortality after 7–14 days
	Chemosterilant	Adjunct			
	Percent	*Percent*		*Percent*	*Percent*
SERIES 1.—APHOLATE PLUS ANTIMETABOLITES, SYNERGISTS, HORMONES, AND OTHER AGENTS					
Apholate	1	.....	H_2O	28	16
Do	1	.....	Methanol	62	5
Do.[1]	1	.....	....do	51	3
Do.[2]	1	.....	....do	9	2
Apholate plus—					
Piperonyl butoxide	1	1	....do	100	30
Do.[1]	1	.....	....do	59	11
Do.[2]	.....	.....	....do	15	6
Propyl isome	1	1	....do	100	40
Do.[1]	1	1	....do	43	1
Do.[2]	1	1	....do	13	4
Sesamex	1	1	....do	100	40
Do.[1]	1	1	....do	66	3
Do.[2]	1	1	....do	17	6
2-(Butoxyethoxy)ethyl piperonylate (Bucarpolate)[2]	1	1	....do	86 64 15	15 4 10
Aminopterin (*N*-[*p*-[[2,4-diamino-6-pteridinyl) methyl]amino]benzoyl]glutamic acid	1	1	H_2O	66	15
Sulfanilamide	1	1	H_2O	22	30
8-Bromoguanine	1	1	H_2O	25	15
Methotrexate	1	1	H_2O	24	30
8-Azaguanine (5-amino-*v*-triazolo[4,5-*d*] pyrimidin-7-ol)	1	1	H_2O	21	45
6-Mercaptopurine (purine-6-thiol)	1	1	H_2O	52	30
5-Amino-4-imidazolecarboxamide	1	1	H_2O	14	40
Hydroxyurea	1	1	H_2O	30	0
Abscisic acid ((*E*,*E*)-5-(1-hydroxy-2,6,6-trimethyl-4-oxo-2-cyclohexen-1-yl)-3-methyl-2,4-pentadienoic acid)	1	.004	H_2O	9	10
Check	.....	.....	Methanol H_2O	11 14	14 12
SERIES 2.—APHOLATE PLUS RADIOPROTECTIVE AGENTS					
Apholate plus—					
N-Acetylcysteine	1	1	H_2O	2	0
DL-penicillamine (3-mercaptovaline)	1	1	H_2O	18	0
Glutathione	1	1	H_2O	8	5
L-cysteine	1	1	H_2O	28	0
2-Mercaptoethylamine hydrochloride	1	1	H_2O	16	10
2-Aminoethanediol hydrochloride	1	1	H_2O	51	10

See footnotes at end of table.

TABLE 2.—*Additive effects of various chemical combinations at substerilizing doses on boll weevils by dipping. (1 replication of 20–50 weevils per test)*—Continued

Compound	Concentration		Solvent	Sterile eggs	Mortality after 7–14 days
	Chemosterilant	Adjunct			
	Percent	*Percent*		*Percent*	*Percent*
Cystamine dihydrochloride (2,2′-dithiobis (ethylamine) dihydrochloride)	1	1	H_2O	52	10
Carbazole	1	1	Methanol	78	15
	1	1	DMSO	88	70
	1	2	Methanol	94	10
	1	2	DMSO	84	90
Check			H_2O [3]	2	12
			Methanol [3]	9	8
			DMSO	8	65
SERIES 3.—CARBAZOLE PLUS SOME ALKYLATING AGENTS					
Carbazole		2	Methanol	10	5
Carbazole plus—					
1-[bis(1-Aziridinyl)phosphinyl]-3-(3,4-dichlorophenyl)urea	2	2	....do	55	20
Methiotepa (tris(2-methyl-1-aziridinyl) phosphine sulfide)	1	2	....do	69	10
Tretamine	1	2	....do	75	55
trans-N,N′-Vinylenebis(1-aziridinecarboxamide)	1	2	....do	22	20
Porfiromycin	2	2	....do	34	10
Check			....do	24	0
SERIES 4.—PIPERONYL BUTOXIDE PLUS SOME ALKYLATING AGENTS					
Piperonyl butoxide		1	Methanol	20	45
Piperonyl butoxide plus—					
1-[bis(1-Aziridinyl)phosphinyl]-3-(3,4-dichlorophenyl)urea	2	1	....do	98	90
Methiotepa	1	1	....do	93	80
Tretamine	1	1	....do	[4]	100
trans-N,N′-Vinylenebis(1-aziridinecarboxamide)	1	1	....do	72	45
Porfiromycin	2	1	....do	56	60
Check			....do	21	5
SERIES 5.—THIOUREA PLUS SOME ALKYLATING AGENTS					
Thiourea		2	Methanol	38	10
Thiourea plus—					
1-[bis(1-Aziridinyl)phosphinyl]-3-(3,4-dichlorophenyl)urea [1]	1	2	....do	24	10
Methiotepa	.5	2	....do	28	25
Tretamine	.5	2	....do	30	0
1-Aziridinecarboxamide, *N,N′-trans-N,N′*-vinylenebis(1-aziridinecarboxamide) vinylenebis-, *trans*	.5	2	....do	35	5
Porfiromycin	1	2	....do	54	15
Check			....do	17	5

See footnotes at end of table.

TABLE 2.—*Additive effects of various chemical combinations at substerilizing doses on boll weevils by dipping. (1 replication of 20–50 weevils per test)*—Continued

Compound	Concentration		Solvent	Sterile eggs	Mortality after 7–14 days
	Chemosterilant	Adjunct			
	Percent	*Percent*		*Percent*	*Percent*
SERIES 6.—6-THIOGUANINE (2-AMINOPURINE-6-THIOL) PLUS SOME ALKYLATING AGENTS					
6-Thioguanine	.....	.5	H_2O	32	10
6-Thioguanine plus—					
Apholate	1.0	1.0	H_2O	83	45
Tretamine	.5	.5	H_2O	39	20
1-[bis(1-Aziridinyl)phosphinyl]-3-(3,4-dichlorophenyl)urea	1	.5	Methanol	34	15
"Queen substance" ((*E*)-9-oxo-2-decenoic acid)	1	.5	H_2O	28	15
Check	.....	.....	Methanol	19	25
			H_2O	3	0

[1] Treated male × normal female.
[2] Treated female × normal male.
[3] 3 replications.
[4] No eggs laid.

TABLE 3.—*Effects of 3,4-(methylenedioxy)phenyl derivatives against boll weevils treated topically. (10 pairs of weevils per test; acetone solvent)*

Chemical name	Entomology No. (ENT–)	NIA [1] No.	Concentration	Mortality after 7–14 days	Average egg hatch	Average emerged adults
			Mg. per ml.	*Percent*	*Percent*	*Percent*
3-Acetyldihydro-5-piperonyl-2(3*H*)-furanone	52737–a	[2] 10385	1	30	80	36
		[3] 10385	5	0	84	20
5-Acetyldihydro-5-(6-propylpiperonyl)-2(3*H*)-furanone	52726–a	[2] 39	1	0	80	20
			5	0	88	44
		[3] 39	1	0	84	32
			5	10	100	28
			10	0	84	(4)
2-Chloro-3′,4′-(methylenedioxy)acetanilide	52741	[2] 11167	1	40	97	33
			5	50	71	29
			10	20	85	27
		[3] 11167	1	0	97	7
			5	0	6	7
			10	0	89	17

See footnotes at end of table.

TABLE 3.—*Effects of 3,4-(methylenedioxy)phenyl derivatives against boll weevils treated topically. (10 pairs of weevils per test; acetone solvent)*—Continued

Chemical name	Entomology No. (ENT–)	NIA [1] No.	Concentration	Mortality after 7–14 days	Average egg hatch	Average emerged adults
			Mg. per ml.	*Percent*	*Percent*	*Percent*
2-Chloropiperonyl acetate	52727	[2] 232	1	0	84	32
			5	0	98	28
			10	0	44	24
		[3] 232	1	0	94	28
			5	0	94	34
			10	0	90	24
2-Chloropiperonyl 10-undecenoate	52728	[2] 233	1	40	85	41
			5	20	97	30
			10	30	91	24
		[3] 233	1	0	89	21
			5	0	93	19
			10	0	97	14
α-[(Dibutylamino)methyl]-3,4-(methylenedioxy) phenethyl alcohol	52736	[2] 10374	1	30	89	29
			5	40	81	29
			10	10	81	25
		[3] 10374	1	0	87	17
			5	0	67	7
			10	0	90	3
Diethyl piperonylphosphonate	52739–a	[2] 11003	1	0	80	8
			5	20	73	21
			10	20	78	34
		[3] 11003	1	20	78	25
			5	20	59	7
			10	20	80	13
Diethyl (6-propylpiperonyl)phosphonate	52740	[2] 11005	1	40	91	34
			5	30	82	33
			10	40	95	35
		[3] 11005	1	10	90	10
			5	10	93	17
			10	0	83	10
7,11-Dimethyl-1-[3,4-(methylenedioxy)phenyl]-1,4,6,10-dodecatetraen-3-one	52734–a	[2] 10138	1	0	66	16
			5	0	70	0
			10	0	88	0
		[3] 10138	1	0	80	12
			5	0	69	20
			10	0	74	16
Di-2-propynyl (6-propylpiperonyl)phosphonate	52742	[2] 11507	1	0	57	12
			5	20	58	18
			10	20	54	16
		[3] 11507	1	10	57	14
			5	10	68	18
			10	20	73	16

See footnotes at end of table.

TABLE 3.—*Effects of 3,4-(methylenedioxy)phenyl derivatives against boll weevils treated topically. (10 pairs of weevils per test; acetone solvent)*—Continued

Chemical name	Entomology No. (ENT–)	NIA [1] No.	Concentration	Mortality after 7–14 days	Average egg hatch	Average emerged adults
			Mg. per ml.	*Percent*	*Percent*	*Percent*
Ethyl 2-[3,4-(methylenedioxy)phenyl]-4,6-dioxocyclohexanecarboxylate	52729–a	[2] 8936	1	0	100	(4)
			5	5	92	(4)
			10	0	82	(4)
		[3] 8936	1	10	85	(4)
			5	0	92	(4)
			10	0	88	(4)
α-(Ethylsulfonyl)-4,5-(methylenedioxy)-2-propyltoluene	14722	[2] 46	1	0	96	28
			5	0	95	25
			10	0	90	(4)
		[3] 46	1	0	76	16
			5	0	100	16
			10	10	88	30
N-[2-Hydroxy-3-[3,4-(methylenedioxy)phenyl] propyl]acetamide acetate	52738–a	[2] 10908	1	0	68	(4)
			5	0	81	(4)
			10	0	78	20
		[3] 10908	1	0	68	24
			5	0	76	32
			10	10	63	24
Methylcarbamic acid ester with 3,4-(methylenedioxy)mandelonitrile	52732–a	[2] 10240	1	0	95	18
			5	0	94	12
			10	0	100	20
		[3] 10240	1	10	86	6
			5	0	98	18
			10	0	92	12
1,2-(Methylenedioxy)-4-[2-(octylsulfinyl) propyl]benzene	16634	[2] 1769	1	10	66	22
			5	0	54	30
			10	0	74	24
		[3] 1769	1	0	53	24
			5	0	66	20
			10	0	66	24
4,5-(Methylenedioxy)-α-(phenylsulfonyl)-2-propyltoluene	16015	[2] 78	1	10	77	23
			5	30	85	31
			10	20	99	34
		[3] 78	1	0	93	13
			5	0	90	20
			10	0	92	23

See footnotes at end of table.

TABLE 3.—*Effects of 3,4-(methylenedioxy)phenyl derivatives against boll weevils treated topically. (10 pairs of weevils per test; acetone solvent)*—Continued

Chemical name	Entomology No. (ENT–)	NIA [1] No.	Concentration	Mortality after 7–14 days	Average egg hatch	Average emerged adults
			Mg. per ml.	*Percent*	*Percent*	*Percent*
1,2-(Methylenedioxy)-4-(2-propynyloxy)benzene....	52730	[2] 10060	1	0	45	13
			5	0	82	20
			10	20	84	26
		[3] 10060	1	0	85	(4)
			5	0	81	30
			10	0	72	16
4,5-(Methylenedioxy)-2-propyl-α-(2-propynyloxy)toluene.....	52731–a	[2] 10081	1	20	80	22
			5	10	82	15
			10	20	42	10
		[3] 10081	1	20	71	12
			5	10	65	6
			10	40	34	6
5-Methyl-4-[3,4-(methylenedioxy)phenyl]-*m*-dioxane.....	5535	[2] 202	1	0	84	16
			5	20	90	24
			10	0	88	12
		[3] 202	1	0	88	(4)
			5	0	72	20
			10	20	80	30
cis-2-Phenyl-5-[(6-propylpiperonyl)oxy]-*m*-dioxane.....	52743–a	[2] 16094	1	0	98	16
			5	0	90	12
			10	0	100	16
		[3] 16094	1	0	94	18
			5	0	94	28
			10	0	88	12
6-Propylpiperonyl *o*-benzoylbenzoate.....	16014	[2] 77	1	0	76	20
			5	0	50	19
			10	0	68	32
		[3] 77	1	0	70	28
			5	0	66	20
			10	0	74	44
6-Propylpiperonyl *p*-ethoxybenzoate.....	16020	[2] 98	1	0	96	(4)
			5	0	90	16
			10	10	97	52
		[3] 98	1	0	100	4
			5	10	92	22
			10	0	92	20

See footnotes at end of table.

TABLE 3.—*Effects of 3,4-(methylenedioxy)phenyl derivatives against boll weevils treated topically. (10 pairs of weevils per test; acetone solvent)*—Continued

Chemical name	Entomology No. (ENT–)	NIA [1] No.	Concentration	Mortality after 7–14 days	Average egg hatch	Average emerged adults
			Mg. per ml.	*Percent*	*Percent*	*Percent*
6-Propylpiperonyl laurate	16013	[2] 23	1	20	83	30
			5	20	67	31
			10	0	74	25
		[3] 23	1	0	90	20
			5	0	90	10
			10	0	100	7
6-Propylpiperonyl phenylacetate	16016	[2] 79	1	20	93	32
			5	40	96	24
			10	10	80	31
		[3] 79	1	0	89	14
			5	0	85	26
			10	0	93	20
Sesamex	[2] 20871	.....	1	0	12	([4])
	[3] 20871	.....	1	7	0	([4])
1,2,3,4-Tetrahydro-3-methyl-6,7-(methylenedioxy)-1,2-naphthalenedicarboximide	52735–a	[2] 10365	1	10	76	24
			5	0	83	30
			10	0	91	20
		[3] 10365	1	0	93	20
			5	0	96	20
			10	0	93	([4])
Check [5]	.....	.....	.....	10	83	24

[1] Niagara Chemical Co. number.
[2] Treated male × normal female.
[3] Treated female × normal male.
[4] Discarded plate due to contamination.
[5] 10 replications.

DISCUSSION

The aziridines were the most effective materials screened. However, none of them were more effective than apholate, which unfortunately decreases the vigor of the insect. This is partly due to damage done to the midgut epithelial cells.

Dame and Schmidt (*4*) sterilized two species of mosquitoes—*Aedes aegypti* (L.) and *Anopheles quadrimaculatus* Say—and the house fly (*Musca domestica* L.) by allowing these insects to crawl over metepa-treated surfaces. However, they reported general vigor was greatly reduced. Metepa by dipping proved to be ineffective against boll weevils. When tested by feeding, it was highly effective, but high mortality, reduced vigor, or both resulted.

Tretamine when applied topically sterilized either sex of the screw-worm (*Cochliomyia hominivorax* (Coquerel)) with low toxic effects (Crystal *3*). It was tested against the boll weevil by dipping and feeding and was found to be highly effective as a sterilant, but again toxicity was high. In one test high sterility was

attained with little mortality; however, this could not be explained.

In addition to tretamine, two other aziridinyl compounds showed good sterilizing ability with little mortality to the weevil. They were 1-aziridinecarboxamide, *N,N'*-1,5-naphthylenebis- and urea, 1-[bis(1-aziridinyl)phosphinyl]-3-(3,4-dichlorophenyl)-. These compounds, like tretamine, reduced vigor and became more toxic as high levels of sterility were attained.

Hempa inhibited oviposition and egg hatch of the house fly at concentrations of 0.25–1 percent (Fye and others *5*) when incorporated in fly food or sugar. It was tested on the boll weevil and found to sterilize effectively at higher concentrations, but toxicity was excessive at these levels.

Low concentrations of apholate and other promising alkylating agents were tested in conjunction with low concentrations of synergists, antimetabolites, hormones, and radioprotective agents with the idea that sterility could be augmented without increased mortality. In these combinations where sterility was increased, mortality also was increased. Also, combination tests were run against mixed sexes and in addition some compounds were tested against individual sexes. Generally males were more effectively sterilized than females. For example, apholate plus piperonyl butoxide when tested against mixed sexes caused 100-percent sterility; against males sterility was 59 percent, and against females it was 15 percent. Apholate was the most effective in combination with insecticide synergists, and mortality was generally lower than with other alkylating agents.

Generally the synergists, such as piperonyl butoxide and propyl isome, were less effective when tested in combination with the alkylating agents than were the insecticide agents.

No protection was afforded by radioprotective agents. Generally mortality was the same as with apholate alone, and the insects were no more vigorous. Neither was there any augmentation of sterility.

When methyl 10,11-epoxy-7-ethyl-3,11-dimethyl-2,6-tridecadienoate (mixed isomers of synthetic juvenile hormone) was screened against the boll weevil by topical application at 0.001 percent, no sterility was noted against either sex, despite the fact that Bowers (*2*) noted some sterilizing effects against female house flies by feeding. However, the failure of this material to sterilize was probably due to the method of administration. Conceivably it would have shown more effectiveness if fed.

SUMMARY

Over 200 candidate chemosterilants or other known biologically active compounds have been evaluated alone and in various combinations against the boll weevil (*Anthonomus grandis* Boheman).

Twenty-seven of the compounds tested either alone or in combination with other compounds were found to sterilize 75 percent of the eggs collected from the test insects, but toxicity to the treated weevil was higher than 30 percent except in six specific tests.

A 12-percent concentration of 1-aziridinecarboxamide, *N,N'*-1,5-naphthylenebis-, a 1.5-percent concentration of tretamine, and a 10-percent concentration of urea, 1-[bis(1-aziridinyl)phosphinyl]-3-(3,4-dichlorophenyl)-when tested against mixed sexes by dipping were found to effectively sterilize 91, 93, and 100 percent of the eggs collected, respectively, and mortality was 12, 11, and 14 to 60 percent, respectively, after 14 days.

In combination tests apholate at 1-percent concentrations with either 1-percent concentrations of piperonyl butoxide or Bucarpolate and 2-percent concentrations of carbazole sterilized 100, 86, and 94 percent of the eggs collected, respectively, but mortality was only 30, 15, and 10 percent, respectively.

A 2-percent concentration of busulfan, glycerol trimethanesulfonate, methanediol dimethanesulfonate, and *N,N*-bis(2-hydroxyethyl)-methanesulfonamide dimethanesulfonate when tested against males only by dipping effectively sterilized 60, 50, 68, and 58 percent of the eggs collected, respectively, and mortality was 85, 70, 65, and 55 percent, respectively, after 14 days.

Di-2-propynyl (6-propylpiperonyl)phosphon-

ate at 1, 5, and 10 mg., 4,5-(methylenedioxy)-2-propyl-α-(2-propynyloxy)toluene at 10 mg., and sesamex at 1 mg. per milliliter when tested against males, females, or both reduced egg hatch to about 56, 38, and 6 percent, respectively, as compared to the control.

LITERATURE CITED

(1) Borkovec, A. B.
1966. Insect chemosterilants. Advances in pest control research. V. 7, pp. 16–23, 27–31. Interscience Pub., New York.

(2) Bowers, W. S.
1968. Juvenile hormone: activity of natural and synthetic synergists. Science 161: 895–897.

(3) Crystal, M. M.
1963. The induction of sexual sterility in the screw worm fly by antimetabolites and alkylating agents. Jour. Econ. Ent. 56: 468.

(4) Dame, D. A., and Schmidt, C. H.
1964. Uptake of metepa and its effects on two species of mosquitoes (Anopheles quadrimaculatus, Aedes aegypti) and house flies (Musca domestica). Jour. Econ. Ent. 57: 77.

(5) Fye, R. L., Gouck, H. K., and LaBrecque, G. C.
1965. Compounds causing sterility in adult house flies. Jour. Econ. Ent. 58: 446.

(6) Gast, R. T.
1965. Mass producing artificial diet pellets for adult boll weevils. Jour. Econ. Ent. 58: 1024–1025.

(7) Haynes, J. W., Hedin, P. A., and Davich, T. B.
1966. Hempa and apholate as chemosterilants for the boll weevil. Jour. Econ. Ent. 59: 1014–1015.

(8) Mitlin, N.
1956. Inhibition of development in the house fly by 3,4-methylenedioxyphenyl compounds. Jour. Econ. Ent. 49: 683.

(9) _____ and Baroody, A. M.
1958. The effect of some biologically active compounds on growth of house fly ovaries. Jour. Econ. Ent. 51: 384.

(10) Riemann, J. G., and Flint, H. M.
1967. Irradiation effects on midguts and testes of the adult boll weevil, Anthonomus grandis, determined by histological and shielding studies. Ent. Soc. Amer. Ann. 60: 298–308.

☆U.S. GOVERNMENT PRINTING OFFICE: 1971 O — 385-162